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1. JP10323612A 19981208 METHOD FOR DISPLAY OF COLOR MATCHING MEASUREMENT INFORMATION

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Priority (No,Kind,Date) : JP15037197 A 19970522 X
Application(No,Kind,Date): JP15037197 A 19970522
IPC: 6B 05D 3/00 A
Language of Document: NotAvailable
Abstract:

PROBLEM TO BE SOLVED: To execute color toning precisely in a short time without impairing characteristics of color matching operation by a method wherein an anticipation display color of a color composition composed of a measured color material together with a measured result is displayed on a display following progress of measuring of color matching.

SOLUTION: Blending information is inputted to a measuring means (S1). As the measuring means, for example, an electronic balance or the like can be preferably used (S2). Then, each measured color material amount is converted to a blended ratio of each color material to an amount of all constituted color materials after start of measurement (S3). Then, anticipation spectroscopic reflectance R (λ, θ) is calculated based on the blended ratio of each color material obtained by conversion. In the formula, λ represents a wavelength, and 9 represents a light receiving angle expressed with an appropriate coordinate system (S4). Then, tristimulus values X(θ), Y8(θ), Z(θ) being anticipation color values are calculated from the calculated anticipation spectroscopic reflectance (S5) . Then, the tristimulus values X, Y, Z are converted to R, G, B display colors (S6), which are inputted to a color display.
Legal Status: There is no Legal Status information available for this patent

(19) Japan Patent Office (JP)

(12) Published Patent Application (A)

(11) Utility Model Registration Application Publication Number
Japan Unexamined Patent Publication Heisei 10-323612

(43) Date of Publication of Application
December 8, Heisei 10 (1998)

Request for Examination
Un-requested
Number of Claims: 5
FD
(Number of Pages in the Document: 9 pages)

(21) Application Number
Japan Patent Application Heisei 9-150371

(22) Date of Filing
May 22, Heisei 9 (1997)

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(54) [Title of the Invention]
The method for display of color matching measurement information

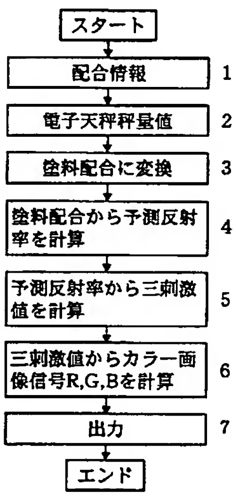
(57) [Abstract]

[Subject]

It is to offer a method for display of color matching measurement information with which it is possible to execute a color toning precisely in a short time and with high efficiency without impairing characteristics of color matching operation which is a sensuous work.

[Solution means]

The method for display of color matching measurement, which is to display a color matching with which a color composition composed of a measured color material from a supplier is adjusted, and which is to display an anticipation display color of a color composition composed of a measured color material and/or a color value together with a measurement result on a display following the progress of measuring of the above-mentioned color matching.



Start
Blending information 1.
Electronic balance weighing value 2.
Change into paint combination. 3.
Calculate anticipation spectroscopic reflectance from the paint combination. 4.
Calculate tristimulus value from the anticipation spectroscopic reflectance. 5.
Calculate display color signals R, G, and B from the tristimulus value. 6.
Output 7.
End

[Claim]
[Claim 1]
The method for display of color matching measurement, which is to display a color matching with which a color composition composed of a measured color material from a supplier is adjusted, and which is to display an anticipation display color of a color composition composed of a measured color material together with a measurement result on a display following the progress of measuring of the above-mentioned color matching.

[Claim 2]
The method for display given in Claim 1 with which display color of an anticipation color and/or a color value are displayed together.

[Claim 3]
When measuring color of automobile refinish paints by matching a blending combination in order to recreate the target color with solid paints and a blending combination in order to recreate the target hue and the brightness with metallic pearl paints, and then by matching color materials to the specified quantity with an electronic balance according to the measured blending combination, the method for display of color matching measurement information of automobile refinish paint which is characterized that it calculates an anticipation spectroscopic reflectance and/or an anticipation color value of a color composition during the measurement before it reaches the measured amount or a color composition which is composed of color materials measured until it reaches the measured amount together with the above-mentioned measured amount by a computer, and comparatively displays the above-mentioned anticipation spectroscopic reflectance or the anticipation display color calculated from the anticipation hue to the above-mentioned target hue on the display following the progress of measuring of the above-mentioned color matching.

[Claim 4]
The method for display of color matching measurement information of automobile refinish paint given in Claim 3 which comparatively displays an anticipation display color of metallic pearl paints calculated from an anticipation spectroscopic reflectance or a anticipation color value on a display at multiple light receiving angles by following the progress of measuring of a color matching.

[Claim 5]
The method for display of color matching measurement information of automobile refinish paint given in Claim 3 which calculates a display color from a spectroscopic reflectance or a color values obtained by linear interpolating from the anticipation spectroscopic reflectance and/or the anticipation color value at multiple light receiving angles and displays the display colors which reaches to a shade direction from a high-light direction though a front direction as a set of images on a display while comparatively displaying an anticipation display color of metallic pearl paints calculated from an anticipation spectroscopic reflectance or a anticipation color value on a display at multiple light receiving angles by following the progress of measuring of a color matching.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention]

This invention is about the method for display of color matching measurement information which is used for color matching with which a color composition composed of a measured color material from a supplier is adjusted.

[0002]

[Prior Art]

Color compositions, such as paints and colorants, are prepared by blending and combining multiple color materials.

When preparing them, it is necessary to control the preparation of color material precisely in order to perform a color toning to desired colors.

[0003]

Generally, color materials are blended one by one according to the amount to be blended until it reaches the target color, and a very small amount of components are added at the end while checking the change in colors in order to obtain the target color toning results from the color toning process, and the process required the skills, intuitions and experiences.

[0004]

For example, although automobile refinish paints are used for refinishing partial or all of an exterior of a car for repairs or upgrades, it is usually required to recreate the same color as the color coating the surface for the automobile refinish.

For this reason, years of experience and intuition are required for the color toning of the paint for repairs, and it is a process which takes extreme skills.

[0005]

On the other hand, differentiations of automobiles have been increasingly progressing in recent years, and the diversification of the kind of paint colors or paints also progressed with diversification of automobiles.

Therefore, it is increasingly requested that the color toning of the paints for repair should correspond to various paints and paint hues.

[0006]

Moreover, when performing automobile repair as work, it is indispensable to process a request of repair efficiently, and to improve the accuracy of repair, and to gain satisfaction from customers.

Furthermore, in order to attain rationalization of this preparation process, necessities, such as a device of the working method which does not require skills as much as possible, laborsaving, and rationalization of the process, are increasing every year.

[0007]

In such a case, in order to satisfy both the above-mentioned requests and to make the repair work more efficient, it is necessary to introduce a color matching system which is capable of performing economic color matching without impairing characteristics of color matching operation which is fundamentally a sensuous work while making it possible to execute color toning precisely in a short time by anyone with the least amount of processes which require the experiences and the intuitions.

[0008]

However, the display of a color matching measurement information based on an anticipation combination at the time of preparing coloring materials and bright materials, in order to attain the color and the brightness which are the same as the target color was extremely inadequate, therefore, in order to attain the combination with which the target color and brightness are fully matched, it was necessary to repeat the color matching measurement several times and to check it as a comparison to the target color by actually using a color card.

[0009]

Especially, unlike the color-creating color design, the color of automobile repair paints is very important to match the color of the paints on the automobile to be repaired.

The color which is actually painted is not the same as the color originally painted because of the fading or discoloration over time in many cases, and therefore, it is necessary to check whether to match the color to the actual color of the automobile to be repaired or not to by the comparison to the paint obtained by the actual color matching process. For this reason, many trials are required to reach the target combination, and the increased time and process of the color matching process have been a cause in the increasing cost.

[0010]
[Problem to be Solved by the Invention]

This invention is to examine the above-mentioned condition, and to offer a method for display of color matching measurement information with which it is possible to execute a color toning precisely in a short time and with high efficiency without impairing characteristics of color matching operation which is a sensuous work.

[0011]

[Means for Solving the Problem]

This invention is about a method for display of color matching measurement, which is to display a color matching with which a color composition composed of a measured color material from a supplier is adjusted, and which is to display an anticipation display color of a color composition composed of a measured color material and/or a color value together with a measurement result on a display following the progress of measuring of the above-mentioned color matching.

[0012]

When measuring color of automobile refinish paints by matching a blending combination in order to recreate the target color with solid paints and a blending combination in order to recreate the target hue and the brightness with metallic pearl paints, and then by matching color materials to the specified quantity with an electronic balance according to the measured blending combination, this invention is also about a method for display of color matching measurement information of automobile refinish paint which is characterized that it calculates an anticipation spectroscopic reflectance and/or an anticipation color value of a color composition during the measurement before it reaches the measured amount or a color composition which is composed of color materials measured until it reaches the measured amount together with the above-mentioned measured amount by a computer, and comparatively displays the above-mentioned anticipation spectroscopic reflectance or the anticipation display color calculated from the anticipation hue to the above-mentioned target hue on the display following the progress of measuring of the above-mentioned color matching.

This invention is explained in more detail below.

[0013]

[Embodiment of the Invention]

In this invention, when adjusting compositions of color materials, such as paints and colorants, color matching measurement information is displayed one by one following the progress of measurement in the color matching process to adjust a color composition to a predetermined color.

The method this invention can be typically shown by Fig.

First, the blending information is inputted to a measuring means (Step 1).

As the above-mentioned measuring means, it is desirable to be able to take measurement results as electric signals immediately, (Step 2), and for example, an electronic balance or the like can be preferably used.

Moreover, when measuring color materials are in the liquid form, a flux meter or like can be preferably used.

In addition, measuring means, such as magnetic, optical, and electromagnetic, can also be used suitably.

[0014]

In addition, the above-mentioned color composition materials are supplied from a supplier which is not shown in the figures and are introduced to the above-mentioned measuring means.

However the above-mentioned supplier is not especially limited, it is desirable to be able to control the supply of color material by corresponding to the signal of supply start and supply stop.

[0015]

Next, each measured color material amount measured by the above-mentioned measuring means is converted to a blended ratio of each color material to an amount of all constituted color materials after start of measurement.

The above-mentioned conversion of all color materials can be done with a computer by using measuring means capable of calculating the blended ratio of each color materials which are already measured at suitable measurement intervals, for example, at every time a fixed measure is carried out, or at every fixed time interval.

This stage corresponds to the step 3 in Fig. 1.

[0016]

In addition, the above-mentioned blended ratio does not have to be the blended ratio measured by the measuring means, and for example, when blending information is already known, it is also possible to use it as a blended ratio.

In this case, the input of the blending information may be a numerical input, or may be done by using a graphic user interface (GUI) on displays, for example by moving a position of sliders or by changing the length of display bars.

[0017]

Next, anticipation spectroscopic reflectance R (λ, θ) is calculated based on the blended ratio of each color material obtained by the above-mentioned step 3.

In the formula, λ represents a wavelength, and θ represents a light receiving angle expressed with the appropriate coordinate system.

This calculation is performed using a computer which is not illustrated in the figures.

This process corresponds to the step 4 in Fig. 1.

Hereafter, an automobile refinish paint is used as an example, and this process is explained in more detail.

[0018]

When matching colors of automobile refinish paints, first a blending combination is calculated with solid paints in order to recreate the target color and a blending combination is calculated with metallic pearl paints in order to recreate the target hue and the brightness, and then color materials are measured based on these blending combinations with an electronic balance until they reach the predetermined amount.

[0019]

With solid system paints

When the paint to be used is a solid system paint, spectroscopic reflectance of the color materials are read from the color data file mentioned later based on the above-mentioned paint blending combination, and then the anticipation spectroscopic reflectance of the above-mentioned paint blending combination is calculated by using the optical density formula of Kubelka-Munk listed below.

[0020]

In this case, optical density formula of Kubelka-Munk can be expressed like the below.

$$(K/S)\lambda = (1-R\lambda)^2/2R\lambda \quad (0<R\lambda<1)$$

In the above formula, λ (K/S) represents the optical density of Kubelka-Munk in the wavelength λ, and Rλ represents a reflectance in the wavelength λ.

By the above-mentioned optical density formula of Kubelka-Munk, the spectroscopic reflectance of the color material basic date in the above-mentioned color date file can be converted into a optical density K/S which are the ratio of the absorption coefficient K and the dispersion coefficient S of a coloring layer, then a optical density at the time of blending can be calculated from by the 2 constant method which is the color theoretical formula of Duncan, and finally as anticipation spectroscopic reflectance at the predetermined blend by converting the above into a reflectance factor.

[0021]

Here, after correcting the influence in the interface of a resin layer and an air layer and converting it to the reflectance in an ideal state by using correction formula of Sanderson, it is possible to used the above-mentioned mixed color theoretical formula in order to improve the anticipation accuracy.

[0022]

With metallic pearl system paint

On the other hand, when the paint to be used is a metallic pearl system paint, it is necessary to perform a color measurement of paint which is consisted of several coloring materials and bright materials.

Here, in order to match the target color and the target brightness to the target paint, the blending ratio of the coloring materials and bright materials should be calculated by
(i) calculating a spectroscopic reflectance of the target paint to several pairs of irradiation angles and light receiving angles by using a spectrophotometer capable of performing color matching at several light receiving angles, and
(ii) calculating the blending ratio of coloring materials and bright materials while anticipating the anticipation spectroscopic reflectance from the blending ratio of the coloring materials and the bright materials so that it matches the above spectroscopic reflectance distributions.

[0023]

In the above-mentioned (i), the color measuring of the target paint with paint coat containing bright materials can be done by using a photometer, for example, polyangular photometer, bending photometer, or the like which is capable of fixing the irradiation angle of irradiation light and of performing a color measuring at multiple light receiving angles, for example, 3-4 or more light receiving angles including a high light direction, a front direction, and a shade direction.

The above-mentioned polyangular photometer and bending photometer is capable of performing a color measuring at multiple light receiving angles while fixing an irradiation angle of an irradiation light.

Therefore, the obtained spectroscopic reflectance R generally can be expressed by the following.

$$R=R(\theta_{in}, \theta_{out}, \lambda)$$

In the above formula, θ_{in} represents an irradiation angle of a sample side from a normal line direction,
θ_{out} represents a light receiving angle of a sample side from a normal line direction,
and λ represents a wavelength.

[0024]

In the above-mentioned (ii), in order to calculate an anticipation spectroscopic reflectance when blending coloring materials and brilliances materials at a prescribed ratio, a basic date spectroscopic reflectance Rb of brilliances materials and a basic date spectroscopic reflectance Rg measured from the coloring materials blended to the brilliances materials should be stored beforehand in the memory of a computer.

These basic data is expressed by the followings. \

$$Rb = Rb(\theta, \lambda, x)$$
$$Rg = Rg(\theta, \lambda, x, y)$$

In the above formula, θ represents a light receiving angle θ,
x represents a concentration of a bright material,
y represents a concentration of a coloring material, and
λ represents a wavelength.

[0025]

Moreover, with the spectroscopic reflectance Rb and Rg of paints containing bright materials, the measurement value of a spectrophotometric color may exceed 100% easily when a light receiving angle is close to a right reflection, and for this reason, it is preferable to set the above-mentioned Rb and Rg by applying an orientation - trap model in this invention.

That is, scatter reflections to various angles to an irradiation light in a paint layer depending on a shape of bright materials or paint conditions.

Moreover, the irradiation light comes into an empty space of bright materials are trapped in the empty space.

By taking these factors into consideration, the spectroscopic reflectance Rb_{true} of bright materials in an ideal state can be expressed by the following.

$$Rb_{true}(\theta, \lambda, x) = I_0(\theta, \lambda) / I_1(\lambda) = C(\theta, \lambda) \times [1 - Tr(\lambda, x)] \times R_m(\theta, \lambda)$$

In the above formula, $I_o(\theta, \lambda)$ represents a euphotic energy of a light to be observed at the wavelength λ and the light receiving angle θ,
$I_1(\lambda)$ represents an irradiation energy of a light to be observed at a wavelength λ,
C (θ, λ) represents a dispersion orientation function of a light by bright materials,
Tr (λ, x) represents a trap effect of a light to be observed with the bright material concentration x,
and $R_m(\theta, \lambda)$ represents a peculiar reflectance of bright materials.

It is also possible to calculate the spectroscopic reflectance Rg_{true} of the above-mentioned Rg in an ideal state by the same way.

[0026]

Therefore, absorptivity A by coloring materials becomes like the following from the bacic date spectroscopic reflectance Rb of bright materials and the spectroscopic reflectance Rg of coloring materials blended to the bright materials which are calculated by the above-mentioned correction.
\

$$A=Rg(\theta, \lambda, x, y)-Rb(\theta, \lambda, x)$$

When using a coloring material with high permeability and low dispersion ability, the theory of Lambert-Beer becomes possible, and it can be expressed as the following.

$$Abs(\theta, \lambda, x, y)=-\log(T)$$

In the formula, Abs (θ, λ, x, y) represents an absorbancy spectrum of coloring materials mixed with bright material, and
T is a transmissivity and has the relation of T=A-1 to the absorptivity A.

Here, by making the length of light path in a paint layer and a peculiar absorbancy spectrum of coloring materials, the following can be attained.

$$Abs(\theta, \lambda, x, y)=L(\theta, x)\cdot y\cdot Abs(\lambda)$$

In the formula, Abs (θ, λ, x, y) is the same as that of the above, and
L (θ, x) represents a length of a light path with a consideration of bright materials in a paint layer.

Abs (λ) represents a peculiar absorbancy spectrum of coloring materials.

The above L (θ, x) of the bright materials should be calculated by using standard coloring materials.

[0027]

Based on the above-mentioned consideration, an absorbancy spectrum at the time of blending n kinds of bright materials and m kinds of coloring materials become the following.

$$Abs_M(\theta, \lambda, x_1, x_2\cdots x_n, y_1, y_2\cdots y_m)=\Sigma L_i(\theta, x_i)/\Sigma x_i\cdot\Sigma[y_j\cdot Abs_j(\lambda)]$$

The description of the notations corresponds to the above in this formula.

The sum is taken to n about I and to m about j.

The anticipation spectroscopic reflectance, therefore, can be calculated from the above-mentioned absorbancy spectrum Abs_M (θ, λ, x1, x2, ••• xn, yl, y2 ••• ym) with the consideration of the above-mentioned theory of Lambert-Beer.

The step12 represents this process in Fig. 2.

[0028]

By the way, the degree of diffuse reflection changes depending on the amount of bright materials added, and the spectroscopic reflectance at each light receiving angle changes.

Usually, since the scattering power per unit area in a coloring layer becomes higher as the density of the bright materials in the coloring layers becomes higher, the diffuse reflection because of the bright materials increases, and therefore the brightness can be improved.

When the amount of bright materials added is increased enough and the dispersion ability reaches is saturated, the brightness will not be improved anymore even by adding more bright materials to it.

Therefore, the relation of the change in the brightness to the amount of bright material added is proportional until it reaches the saturation, and it becomes a monotone increasing function where the primary differentiation is positive and the secondary differentiation is negative.

Then, by calculating a basic data of a spectroscopic reflectance at each irradiation angle and each light receiving angle when gradually increasing the amount of bright materials added, as it is shown by the following, it is possible to anticipate a flop vale F to the concentration x of bright materials from the relation f in between the concentration x of bright materials and the flop value F expressing the brightness.

$$F = f(x)$$

In the above formula, f is a presumed function of a flop value.

The step 13 represents this process in Fig. 2.

[0029]

In this case, the presumed function of a flop value can be calculated by matching a flop value to the concentration of bright materials measured discretely beforehand.

This matching can be based, for example, on a primary interpolation etc.

Here, in order to improve the accuracy of interpolating, since it becomes easy for a flop value F_1 to create a proportionality relation with the amount of bright materials added when converting the flop value F to the flop value F_1 by a monotone increasing function where the primary differentiation is positive and the secondary differentiation is close to negative to the amount x of bright materials added, it becomes easy to attain an additivity of each converted flop value F_1 to create when added several bright materials, and therefore, the anticipation of a flop value at the time of adding several bright materials can be more accurate.

[0030]

Therefore, when measuring a blending combination of a paint consisted of coloring materials and bright materials, it is possible to anticipate and calculate the target spectroscopic reflectance and a blending combination which becomes the target flop value while taking consideration of the changes of the spectroscopic reflectance at each light receiving angle generated according to the change in the amount of bright materials to be added.

[0031]

By correcting the anticipated measurement results calculated theoretically like the above by introducing a calculation technique using Fuzzy Logic, it becomes possible to actually improve the accuracy of a color matching.

When calculating a anticipation spectroscopic reflectance, after storing a date about a blending ratio of coloring materials or bright materials and a bending spectroscopic reflectance and a polyangular spectroscopic reflectance obtained by changing a paint condition in a memory of a computer, the difference with the anticipated results measured by following the above-mentioned theory can be corrected by using Fuzzy Logic with this technique.

The step of 14 represents this process in Fig. 2.

Hereafter, this process is explained in more detail.

[0032]

The block diagram of Fuzzy Logic is shown in Fig. 3.

With Fuzzy Logic, ambiguity is defined by using Membership function in Fuzzy Set Theory.

When applying it to the logic, Fuzzy Production Rule is defined by using this Membership function.

This Fuzzy Production Rule is consisted of an antecedent part and consequent part, and, generally is expressed with the following formula.

Since the following formula is simplified, the case of the antecedent part 2 and the consequent part 1 is shown.

$$R_i : \text{if } a_1 \text{ is } A_{i1} \text{ and } a_2 \text{ is } a_{i2}$$
$$\text{then } b \text{ is} B_i \ (i=1, 2 \cdots n)$$

In the above formula,
R_i represents the i-number of Fuzzy Production Rule,
a_1 represents a concept of the antecedent part 1,
a_2 represents a concept of the antecedent part 2,

A_{i1} represents the i-membership function (Fuzzy Label) of the antecedent part 1,
A_{i2} represents the i-membership function (Fuzzy Label) of the antecedent part 2,
b represents the concept of the consequent part,
B_i represents the i-membership function (Fuzzy Label) of the consequent part, and
n represents the number of Membership Functions (Fuzzy Label).

When performing the above-mentioned correction, the antecedent part of Fuzzy Production Rule should be consisted of kinds of coloring materials, kinds of bright materials, and a film thickness, and the consequent part is considered as a correction value.

[0033]

Fuzzy Label of the coloring materials, white paints, and the bright materials at the antecedent part is an expression of "many" and "few" about coloring material, white paints, and grade is added to it.

As for the thickness t of a coating film, it may be an actual measurement, or may also be a suitable index, for example, a number of bar coater etc.

Fuzzy Label is set by anticipating the range of coating film and by dividing it into regular intervals or non-regular intervals.

As for the bright materials, it is desirable to set Fuzzy Label by anticipating the maximum amount of it to be added and by dividing it into regular intervals or non-regular intervals.

[0034]

Fuzzy Label at the consequent part expresses the degree of the difference in between the optical concentration calculated from an actual spectroscopic reflectance of a color card created in a specific condition and the optical concentration theoretically calculated from the preparation condition.

[0035]

In Fuzzy Logic, each conception of the antecedent part is fuzzyfied from the difference in between the target value and the result value by Membership Function, and then by using Fuzzy Production Rule which is prepared beforehand, the measures to a specific condition can be determined, for example, by reducing the amount of coloring material to be added when there is too much of it.

Then, Membership Function of the consequent part will be set aside.

And the amount of the corrections in the amount of colorings is determined from this function set aside.

[0036]

Also as for the flop value F, the exact anticipation flop value F can be calculated by calculating the correction function of the flop value by Fuzzy Logic.

[0037]

Therefore, it is possible to form a theoretical calculation at the wavelength λ measured at the above and an inference mechanism for correcting from the actual measured optical concentration, and especially in the color measuring of an automobile refinish paint, it is possible to improve the accuracy and the time of color matching calculation in order to match it to the target color and the target flop value even when using a date from polyangular photometer with this method.

[0038]

When calculating the above-mentioned anticipation spectroscopic reflectance by using a computer, it is preferable that a color date film is installed to the above-mentioned computer in this invention.

The above-mentioned color data file should at least include a coloring material basic data file, a bright material basic data file, a white paint basic data file, and a record learning data file.

The above-mentioned coloring material basic data file, the bright material basic data file, and the white paint basic data file are consisted of a spectroscopic reflectance date of visible wavelength ranges of each coloring material, bright material, and white paint at several angles.

The above-mentioned spectroscopic reflectance can be measurement values at 3 to 4 different light receiving angles, for example at 20°, 45°, 75°, and 110° light receiving angle from the specular reflection direction when irradiating an incidence light at the angle of 45° from the normal line direction of a sample.

Moreover, it is also possible to use a color measuring data obtained by a bending photometer.

[0039]

The above-mentioned record learning data file is consisted of spectroscopic reflectances of already prepared sample several color cards by the above method which are consisted of a suitable blending ratio of coloring materials and bright materials and of coating conditions for the color card preparation, and is used for correction calculation using Fuzzy Logic.

[0040]

In addition, the above-mentioned computer is not especially limited, and a personal computer can be used in this invention.

As for the above-mentioned personal computer, a computer which has a CPU with 166MHz or more of clock frequency, an internal memory of more than 16MB or preferably more than 32 MB, and a hard disk drive with 1 GB of more is preferably used.

[0041]

In color matching of an automobile refinish paint, the color materials are measured until it reaches the predetermined amount by an electronic balance based on the paint blending combination calculated by the above method.

The above-mentioned electronic balance is not especially limited, and it is preferable to use an explosion proof type electronic balance.

Here, even when the above-mentioned measurement is still in progress, a halfway anticipation display color of color materials which are supplied to an electronic balance from supplier of color materials along with an anticipation display color of a calculated paint blend is comparatively displayed on a display in real time with the matching result following progress of measuring of color matching in this invention.

Hereafter, the method of displaying this halfway anticipation display color on a display is explained in more detail.

[0042]

The amount of color material measured with the above-mentioned electronic balance is converted into a blended ratio of each color material to an amount of all constituted color materials measured after the start of the measurement.

Although the above-mentioned conversion is performed for every suitable measurement interval or suitable time interval, it is preferable to perform it, for example, for every 0.1g measurement, or for every 1 second when considering the calculation time of the anticipation spectroscopic reflectance.

The above-mentioned conversion is performed by calculating the blended ratio of all color materials and bright materials to the amounts of all color materials which are already measured at this point of time.

[0043]

Based of the blended ratio obtained by the convention in the above-mentioned step, anticipation spectroscopic reflectance $R(\lambda, \theta)$ of this ratio is calculated by the above-mentioned calculation method of an anticipation spectroscopic reflectance.

In the formula,
λ represents a wavelength,
θ represents a light receiving angle expressed with the appropriate coordinate system.

[0044]

Next, tristimulus values X(θ), Y8(θ), Z(θ) which are the anticipation color values are calculated from the calculated anticipation spectroscopic reflectance R (λ, θ).

This step corresponds to the process 5 in Fig. 1.

In order to calculate tristimulus values X(θ), Y8(θ), Z(θ) from anticipation spectroscopic reflectance R (λ, θ), the formula listed below is used with functions x (λ), and y (λ) and z (λ).

In addition, the above-mentioned θ here can be calculated at 20°, 45°, 75°, and 110° from the right reflection to several suitable light receiving angles, for example, to 45° incidence from the normal line.

Therefore, θ is omitted from the following formula.

$$X = k \int R(\lambda) \cdot P(\lambda) \cdot x(\lambda)\, d\lambda$$
$$Y = k \int R(\lambda) \cdot P(\lambda) \cdot y(\lambda)\, d\lambda$$
$$Z = k \int R(\lambda) \cdot P(\lambda) \cdot z(\lambda)\, d\lambda$$

k is a specific constant so that the value of y is set to be 1 in the white perfect reflecting diffuser (λ= 400-700nm) of R(λ) = 1 in the formula.

P (λ) represents a spectral distribution of illumination light, and
R (λ) represents an anticipation spectroscopic reflectance of the above-mentioned ratio.

In addition, the integration is performed in a visible light wavelength region.

[0045]

Next, the tristimulus value X and Y and Z calculated in this way, are converted into values of R, G, and B display colors, and the color display signal which can be inputted into a color display is calculated.

The above-mentioned color display signal is inputted into a display as a RGB input.

[0046]

The each above-mentioned color display signal, or R, G, and B display colors, with a full color is displayed at 8 bits and has a value of 0-255.

[0047]

The conversion for converting the tristimulus values X, and Y and Z into the values of R, G, and B display colors is a matrix type conversion and can be performed by 3x3 conversion matrix can perform it.

This step corresponds to the process 6 in Fig. 1.

[0048]

By the way, the color display signal of a display generally is not necessary to be in a proportionality relation with the bright luminosity of each color light displayed on the display.

When the degrees of the brightness are different, there is a possibility that colors may look with man's vision.

Then, it is preferable to correct the relationship between RGB signal levels and the bright luminosity which is very peculiar to this display.

For example, the relation between an impressed electromotive force and fluorescent substance bright luminosity of a display monitor is not a matrix type, and is generally said to have a proportionality relationship to γ -plex of the impressed electromotive force V.

The above γ is the value of 2-3.

Since the impressed electromotive force is proportional to the inputted RGB value, it is thought that the same is said to the relation between a RGB value and a fluorescent substance bright luminosity.

Then, a γ correction is performed in order to change this relation into a matrix type.

The above-mentioned γ correction is performed by a look up table method or a method regression formula.

Furthermore, it is preferable to perform a visual correction also.

[0049]

Therefore, the conversion of the tristimulus values X, and Y and Z into the values of R, G, and B display colors can be performed by the following formula with a consideration of the above-mentioned corrections.

That is, X, and Y and Z are first converted into R', G', and B' by the following formula (1).

Then, a γ correction and a visual correction of these converted R', G', and B' are done by the following formula (2), and the target R, G, B display colors can be obtained.

[0050]
[Formula1]

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = M \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \qquad (1)$$

[0050]
[Formula2]

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} \alpha R'^{\gamma_R} \\ \alpha G'^{\gamma_G} \\ \alpha B'^{\gamma_B} \end{bmatrix} + \begin{bmatrix} C_R(X,Y,Z) \\ C_G(X,Y,Z) \\ C_B(X,Y,Z) \end{bmatrix} \qquad (2)$$

[0052]
In the formula,
M represents a 3x3 conversion matrix obtained with a consideration of the characteristic of a display,
α is a constant,
each γ_R, γ_G, and γ_B expresses γ a correction coefficient corresponding to R, G, and B, respectively,
each C_R (X Y, Z), C_G (X Y, Z), and C_B (X Y, Z) is corrected function which is used to match a display color and a actual color, and also represents a function which is calculated by reading a difference in between a already measured color of a object on a display and R, G, and B signals which match the color visually.

[0053]

The anticipation display color based on the measured R, G, B values are displayed on a display together with a measurement result, or with a display color and/or color numerical value of the target matching color.

As for the display method of the above-mentioned display color, with a metallic pearl paint, an anticipation display color calculated from an anticipation spectroscopic reflectance calculated or an anticipation color value is displayed for multiple light receiving angles, and for example, it is possible to display a display color at 20°, 45°, 75°, and 110° light receiving angles which include a high light direction, a front direction, and a shade direction, from the specular reflection direction when irradiating an incidence light at the angle of 45° from the normal line direction of a sample, or, after calculating a display color from a reflectance or a color value obtained by performing a matrix interpolating the anticipation spectroscopic reflectance or anticipation display color at the above-mentioned multiple light receiving angles, and

it is also possible to display the display colors in the specific range of light receiving angles which reaches to a shade direction from a high-light direction though a front direction as a set of images on a display, and for example, the display colors in the range of 200-110° from the specular reflection direction can be displayed to the light receiving angles continuously.

In this case, the display colors at the above-mentioned θ values are not in 20°, 45°, 75°, and 110°, can be calculated by a matrix interpolating method.

It is possible to perform the above-mentioned matrix interpolating method, for example, by calculating a suitable matrix function of R, G, B value in a range where θ is in between 20° to 45° by using a value with θ at 20° and a value with θ at 45°,

[0054]

In this case, it is also possible to display a color numerical value of this display color, for example, in a form, such a X, Y, Z, and L*a*b*, simultaneously with an anticipation display color or a target color matching color.

Then, it becomes possible to find more exact colors by displaying these display colors in color numerical values.

[0055]

As for the above-mentioned measurement result, it is possible to display it as a measured weight amount, or for example, as a visual display which corresponds to the measured weight amount, such as a change of a length of a bar or a position of a slider display.

[0056]

As for the display method of this invention, since it is possible display an anticipation reappearance color together with a target color at the time of measuring a blended composition on an electronic balance based a target blend combination calculated by the color matching formula, by displaying the anticipation reappearance color corresponding to the blended ration at the time of measuring together with the target color on a color display simultaneously at each light receiving angle, or by displaying the display color in a specific range of light receiving angles as a set of images, it becomes possible to visually check how close the colors which corresponds to the blend combination during the measurement to the target color and to match colors effectively during the measurement.

[0057]

Moreover, as for a correction of a color matching, since it is possible to display an anticipation reappearance color which is very difficult to figure out only with a blend combination numerical value, it is possible to lessen the weight on a process of repeating the color matching and comparing an actual color card and a target color.

Since it is possible to converge the color matching easily when correcting the color matching which usually requires trials and tribulation, it is possible to shorten the time needed for a color matching process especially when matching colors of an automobile refinish paint.

That is, it becomes easy to judge the color visibly when it is necessary to check whether a color matches the actual color of the automobile to be repaired or not to by the comparison to the paint obtained by the actual color matching process since the color of a paint on an automobile to be repaired is not the same as the color originally painted because of the fading or discoloration over time in many cases.

[0058]

Furthermore, since it is possible to visually check how a display color changes immediately with the method of this invention when it is necessary to change or correct a color paint blend combination, it also becomes possible to visually check changes immediatelydepending on the differences in blend combinations immediately, for example, the change in blended paints when changing the amount blended of specific colors.

Here, it is possible to visually check how the display color changes according the addition of specific colors, for example, by checking display colors after inputting a blend combination numerical value or by, for example, moving a position of a slider or changing the length of a display bar by using a graphic user interface on a display,

Therefore, a training support for mastering color matching process easily can be offered.

[0059]
[Execution example]

Although this invention is explained in more datail with execution examples, this invention is not limited these execution examples.

[0060]

Execution example 1

After preparing a personal computer (CPU166MHz, Memory 32MB, Windows 95 loaded) and), a liquid crystal full color display, and an electronic balance (Product of Sartorius, Minimum weight: 0.1g, Maximum weight: 7.2kg), a color matching calculator using Fuzzy Logic with which a color matching of paints containing bright material can be done, and a color date files of color materials and bright materials were loaded to the above-mentioned personal computer.

<u>Preparation of a database</u>

The color measurement date at the concentration listed in Table 1 about the color materials and the bright materials listed in Table 1 were loaded to the color date files of the color materials and the bright materials.

[0061]
[Table 1]

Kind		Concentration (%)
Coloring materials	Shining blue	0, 2.99, 9.99, 29.99. 100.00
	Shadow Green	0, 3.00, 10.10, 29.77, 100.00
	Ketjen black	0, 3.03, 10.39. 29.91, 100.00
Bright material	Detailed aluminum	0, 1.06, 3.06, 5.03, 7.06, 10.01. 20.41, 29.83, 49.83, 69.86, 100.00
	Second-cut aluminum	0, 1.02, 3.04, 5.00, 7.00, 9.99, 19.96, 30.02, 50.03, 69.86, 100.00
	Rough aluminum	0, 1.00, 3.06, 5.01, 7.02, 10.00, 20.06, 30.03, 50.18, 70.03, 100.00

[0062]

Moreover, for Fuzzy Logic, a color matching data of 18 different kinds of actual color cards were also loaded as a track record.

In addition, a color matching of a sample color card prepared by coating a metallic paint on a color card to which a base coat was applied beforehand was performed at 20°, 45°, and 110° light receiving angles from the specular reflection direction at every 10nm between 400 to 700nm by using a polyangular spectrophotometer (CE-741, Product of Macbeth).

[0063]

Execution of Color matching process

After performing a color matching of a target paint with a color matching probe of the polyangular spectrophotometer, and then inputting a data into a computer by setting the color matching probe of the polyangular spectrophotometer to a docking station, directions about a blend combination calculation was given.

After the direction was given, the first calculation result was obtained in about 10 seconds.

Based on this calculation result, it was weighted with the electronic balance in order to prepare a paint.

A color card was prepared in the same way as the target color card by applying this paint.

Next, a correction calculation was performed based on this first calculation result, and after the direction was given, the second calculation result was obtained in about 8 seconds.

Based on this calculation result, it was weighted with the electronic balance in order to prepare a paint.

[0064]

Display of color matching information

The anticipation combination colors in the range of 200 to 110° from the right reflection direction based on the above-mentioned first calculation result while being measured were displayed on a full color display as a set of images continuously to the light receiving angle.

Simultaneously, the target colors in the range of 200 to 110° from the right reflection direction were also displayed on a full color display as a set of images continuously to the light receiving angle.

Moreover, the measurement result of the coloring materials and the bright materials while being weighted was simultaneously numerically displayed together with a value of the target amount on a display following the progress of the measuring of the color matching.

Here, the amount of each coloring materials and bright materials added was displayed on the display also by the change in the length of the display bar.

[0065]

Next, a correction calculation was performed based on this first calculation result, and the second calculation result was obtained in about 8 seconds after the directions were given.

Based on this calculation result, it was weighted with the electronic balance in order to prepare a paint.

Moreover, the anticipation combination color based on the above-mentioned first measurement result while being measured was displayed on a display together with the target color by the same way as the above and was visually checked.

[0066]

When checking the comparative display on the display during these color matching processes, it was possible to visually see the display color during the color matching processes changing following the progress of the measuring and by the addition of each color materials.

Moreover, the amount of each color materials added was visibly checked from the change in the length of the display bar, and it was possible to visually check the color matching process.

[0067]

Moreover, when visually checking the anticipation combination color based on the second calculation result while being measured by displaying it together with the target color, it was at the level where it was impossible to see the differences visually.

From these color matching processes of the color card and the target color card which were prepared based to the second combination calculation result, the color difference ΔE was 1.98 at 20°, 1.07 at 45° and 1.03 at 110°, and as a result of this, it was possible to check that the display color on the display was very close to the color matching result of the color card.

[0068]

[Effect of the Invention]

According to this invention, it is possible to offer a method for display of color matching measurement information to execute a color matching precisely in a short time without impairing characteristics of the color matching operation.

[Brief Explanation of the Drawings]

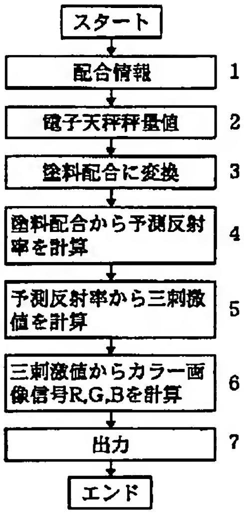
[Fig. 1]
A block diagram showing the display method of this invention.

[Fig. 2]
A block diagram showing the color matching steps for the method of color matching measurement information of an automobile refinish paint of this invention.

[Fig. 3]

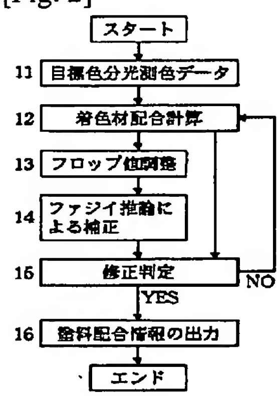
A block diagram showing the correction steps of an anticipation spectroscopic reflectance according to Fuzzy Logic during the color matching steps for the method of color matching measurement information of an automobile refinish paint of this invention.

[Fig. 1]



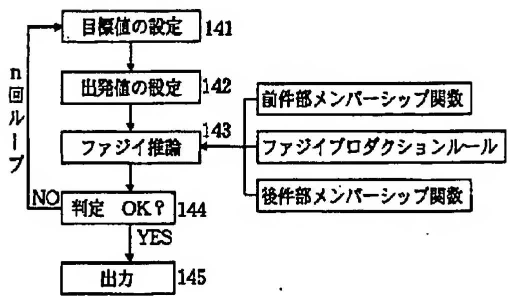
Start
Blending information 1.
Electronic balance weighing value 2.
Change into paint combination. 3.
Calculate anticipation spectroscopic reflectance from the paint combination. 4.
Calculate tristimulus value from the anticipation spectroscopic reflectance. 5.
Calculate display color signals R, G, and B from the tristimulus value. 6.
Output 7.
End

[Fig. 2]



Start
Target color spectrophotometric color data 11.
Coloring material combination calculation 12.
Flop value adjustment13.
Correcting by Fuzzy Logic 14.
Correction judging 15.
Output of paint blending information 16.
End

[Fig. 3]



Setup of desired value 141.
Setup of starting value 142.
Fuzzy Logic 143. Antecedent Part Membership Function
Fuzzy Production Rule
Consequent Part Membership Function

Judgment O.K.? 144.
Output 145.

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